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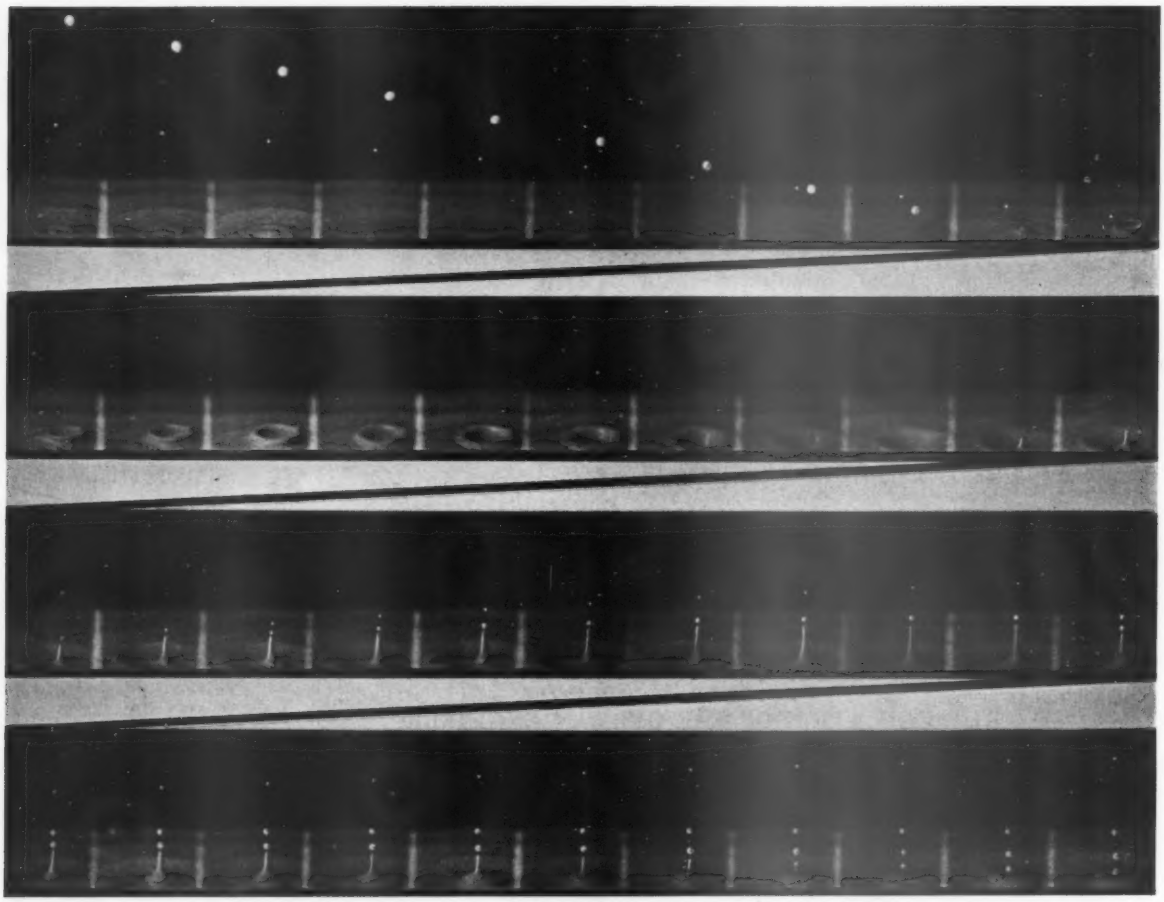
A FALLING DROP OF MILK

Caught in the Act by a New Method of High Speed Photography



ABOVE is shown, from left to right, row by row, 44 separate, successive pictures of a globule of milk dropping into a puddle of milk. When the drop strikes the surface of the puddle a crater is formed as shown in the second row down. There next occurs a conical growth in the center of a crater which resolved into small droplets bouncing upward as pictured in the bottom row. This phenomenon is not observable by the eye, since it takes place too rapidly.

These pictures which reveal it were taken at a speed of 480 exposures a second or nearly 30,000 a minute. Each row of 11 pictures represents a time interval of about 1/45 of a second, and the entire sequence shown above an interval approximately 1/10 of a second.

The camera which was used has no shutter nor any clawing mechanism. The film is simply run through it continuously without stopping for each picture as ordinary motion picture cameras do. The drop being photographed is illuminated by powerful stroboscopic or intermittent light which lasts about 1/100,000th of a second or less for each flash. The instantaneous intensity is sufficient to expose a photograph in this short time and the time of exposure is so short that there is no appreciable blur. In other words, the light is on and off so quickly that a photographic impression of the object is exposed upon the film as though both the object and the film were stationary.

The flashes of light are obtained by discharging condensers through mercury-arc lamps. The circuit is arranged so that the condensers are charged up between flashes. This method of high speed photography has been developed by Harold E. Edgerton, '27, of the Institute's Electrical Engineering Department with the assistance of Kenneth J. Germeshausen, '32.

While there are other methods of high-speed photography with even greater speed, they are complicated and expensive in contrast to the extreme simplicity and portability of this one. The stroboscopic method is finding a great variety of uses in industry, particularly for observing the operation of high-speed machinery, and in making motion studies.

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THE MASTER KEY OF SCIENCE

Revealing the Universe through the Spectroscope

By Henry Norris Russell

THE great French philosopher of the last century, Auguste Comte, was an exceedingly well informed and versatile man, but it was he who once remarked: "There are some things of which the human race must forever remain in ignorance; for example, the chemical composition of the heavenly bodies." To Comte and the other intelligent men of his time, this problem seemed hopelessly insoluble; there was no way of attacking it.

Of course this statement sounds ridiculous to us now. It became ridiculous because man's dream came true of a master key that would unlock many doors, one after another, and so open up many new realms of knowledge.

That master key was the spectroscope. No sooner was it discovered than the composition of the heavenly bodies, previously unknowable, became an open book. With its use, many of the familiar chemical elements were identified in the sun, and not long after, in the stars. Later work has extended the number of elements identified in the sun to sixty, and spectroscopic study has shown that the atmosphere of Mars contains oxygen and water vapor, while that of Venus shows no signs of them.

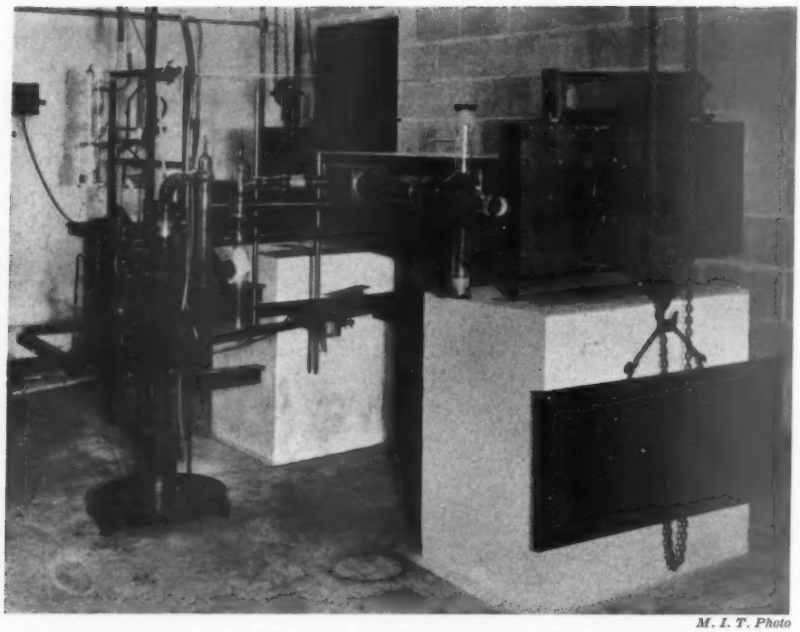
All the stronger lines in the spectra of the sun and stars and a host of the weaker ones have been identified. It has been demonstrated that the same atoms are present on earth that are also present in the remotest nebulae, in the relatively cold tail of a comet, and in the intensely heated surface of a white star. By showing these things, the spectroscope has given the most impressive of all proofs of the unity of nature.

This achievement has been described in poetry, as it should be, by Edmund Clarence Stedman, in one of his more philosophical poems "Corda Concordia." The stanza in which this is done is such good science, as well as such good poetry, that I would like to quote it:

> "White orbs like angels pass
> Before the triple glass,
> That men may scan the record of each flame, —
> Of spectral line and line
> The legendry divine, —
> Finding their mould the same, and aye the same,
> The atoms that we knew before
> Of which ourselves are made, — dust, and no more."

It is more than two hundred years since Newton, passing his beam of light in a darkened room through a prism, saw the rainbow-colored streak of light upon the wall as the rays of different color were refracted in different amount by the prism, and so was led to realize the composite nature of white light. Unfortunately, Newton took his light through a small round hole and he took it from the large round sun; consequently, even if the sun had been all one color, the image that he would have had thrown on the wall would have been like the image that he got when it came through a pinhole in the window shade. If only he had had the wit to set up a narrow slit so that the image would have been sharp and not round, the master key might have been discovered.

Just after the first half of the Nineteenth Century was over, Kirchoff and Bunsen made that simple but fundamental mechanical change. Really this master key was



M. I. T. Photo

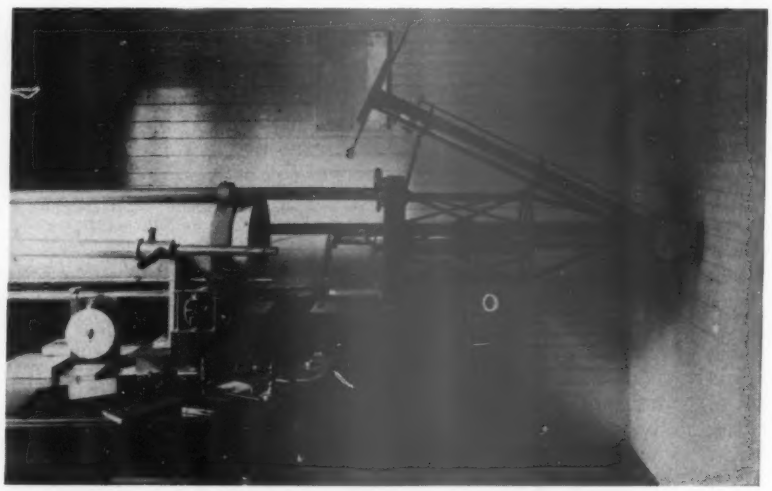
A vacuum spectrograph used for studies in the extreme ultraviolet region of light. It was developed from a design of President Karl T. Compton, of M. I. T., with the assistance of Dr. Joseph C. Boyce, a Research Associate in the Department of Physics. It is in the Spectroscopic Laboratory at M. I. T., a "Science Wonderland," which "represents the heaviest artillery yet concentrated by Science for assaulting the citadel of the atom"

found in a narrow slit — simply in letting your light into this prismatic instrument through a slit so narrow that you obtained a sharply defined image. As soon as that was done, as soon as they took the light through a narrow slit into their prism, with an eyepiece to look at it and a couple of other lenses to make the light go in parallel rays through the prism — the new doors were opened and the new worlds free to conquer.

The next necessary advancement was the development of a more delicate method of spectrum analysis. This came with Rowland, the great Johns Hopkins physicist in the Nineties. He developed an engine for ruling diffraction gratings, the device that is used for breaking light up into its components. The best of Rowland's gratings are the joy, the envy, and the despair of the investigators today — the joy of the man who has one, the envy of his colleagues, and the despair of the man who tries to make one as good. Rowland devoted years to the study of the solar spectrum and reported and recorded in it the position of 20,000 lines, each one carrying its own story of some substance in the sun. When Rowland was through his work, thirty-six of the chemical elements had been identified in the sun. Since that day, of course, a number more have been added because plates have been developed which are sensitive to the red end of the spectrum, and Rowland had no such plates available. Partly for that reason, and partly because some substances are now available of which Rowland could not get specimens, sixty chemical elements have now been identified in the sun — most of them with certainty.

In the stars, we cannot observe such immense detail as we can in the sun, although the big spectroscopes that are now being attached to the great refractors such as the Mt. Wilson 100″ telescope give us an amazing amount of information, and dozens of different chemical elements have been definitely identified in the stars.

The minute shift in the position of the lines due to motions of approach or recession has enabled us to detect and measure the rotation of the sun and the planets, to prove that Saturn's rings are not solid, but composed of myriads of tiny satellites, and to get one of the most accurate determinations of the sun's distance. Applied to the stars, it has determined the sun's motion among them, the distances of hundreds of individual stars, and the average for thousands more; has revealed hundreds of double stars too close to be resolved by the telescope, and determined the masses and even the diameters of some of them; and has disclosed those amazingly rapid motions of the remote nebulae — some as high as 15,000 miles a second — which point the way to new conceptions of the nature, the past and the future of the material universe. Spectroscopic tests have shown that the nebulae are of two kinds, one consisting of masses of luminous gas; the others, giving light



The spectroheliograph invented by George Ellery Hale, '90

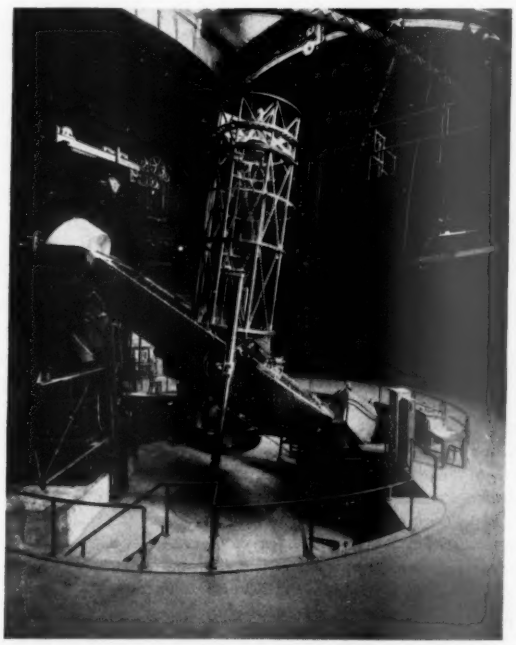
like stars, must themselves be great clusters of stars at gigantic distances.

If the spectroscope has thus proved so profitable to the astronomer, what has it accomplished for scientists in other fields? The chemist owes to spectroscopy the discovery of at least ten of the elements, some by optical methods, others more recently by the aid of x-rays. Among these is helium which was detected in the sun and its nature as a light gas correctly interpreted more than twenty years before it was "run to earth."

The classical physicist finds in the spectroscopic data his most precise standards of length, and some of his more accurate methods of measurement. My friend, Dr. Meggers, of the Bureau of Standards, and his associates have developed this use of the spectroscope recently. Suppose, for example, you have some fusible plugs that are used in our overhead sprinkler systems. They are made of a fusible alloy which will be greatly damaged if it has any more than the most minute quantity of iron in it. To find this out by chemical analysis is a slow and tedious process; but you can take one of these plugs and test it with the spectroscope, and if the strong lines of iron show up, you know there is iron there. Comparative tests with materials of different composition give you an idea of the safe limits. Thus, with the spectroscope you can test these alloys in a minute part of the time that chemical composition requires.

M. I. T. Photo

The great 21′ vacuum spectrograph at M. I. T., the largest ever built. It was designed by Professor George R. Harrison, Director of the Spectroscopic Laboratory. When the cylinder is evacuated, the force exerted by the atmosphere on the outside is approximately 88 tons. The size of this huge spectroscope is indicated by comparing it with the one on the table which is of the size customarily used in this field of research



The great Hooker 100″ telescope at the Mt. Wilson Observatory. It has been enormously valuable in spectroscopic research

But it is in the realm of atomic physics that spectroscopy has played its greatest rôle. Fifty years ago, Lockyer, from a study of the spectra of electric arcs and sparks, and of the stars, concluded that, in the spark and in the hotter stars, ordinary atoms are decomposed into products which give different spectral lines. This bold generalization was fully justified forty years afterward, by the development of the theory of ionization.

About forty years ago, series of lines were detected in many of the simpler spectra, and found to be representable by formulae in which the "Rydberg constant," common to all spectra, appeared. Here was evidence of some uniform feature in the constitution of the different atoms. The Zeeman effect, according to which a spectral line emitted by a source placed in a strong magnetic field is split up into polarized components, again showed features common to different atoms, and suggesting the presence within them of moving electrical charges. The Bohr-Rutherford theory of atomic structure — with electrons in orbital motion around a nucleus — was based very largely on these spectroscopic data. It accounted at once for the typical spectral series of hydrogen, and accurately predicted other series in the infra-red and ultra-violet. With simple modifications, it explained the more complicated system of series in the spectra of the alkalies. The multiple character of the terms of the series was later (*Continued on page 300*)

The Education of the German Engineer

The Evolution of the Technical University. Its Success in Training for Leadership

By Theodor Rehbock

A CENTURY ago there were in Germany no engineers with technical university training, since the higher German technical institutions which provide an education based upon mathematics and the natural sciences have existed little more than 100 years.

Prior to this time, technical experts were developed only through practical, professional life. In that period it was difficult in Germany to adapt fundamental, theoretical knowledge to technical fields of endeavor. An illustration of the extraordinary obstacles met with by progressive engineers before 1825 (the year of the foundation of the polytechnic school, later the *Technische Hochschule*, or Technical University of Karlsruhe) is shown in the development of Johann Gottfried Tulla, the man who first saw the need for technical universities in Germany. His sovereign had commissioned him with the regulation of the waters in the country of Baden, in particular of the Rhine, to protect the land from the heavy damages of the uncontrolled rivers.

To obtain the necessary theoretical knowledge, Tulla was sent abroad by his ruler to a prominent mathematician for private instruction, whereafter he engaged in practical surveying projects on the lower Rhine, followed by considerable traveling in other countries. Finally, to complete his training, Tulla studied at Paris, where higher technical instruction methods had first been developed and were already well advanced by the end of the Eighteenth Century.

Not until after long years of tedious and expensive training could Tulla undertake the organization of river and highway construction in his native Baden, together with the direction of one of the greatest river-hydraulic projects of all times: the regulation of the Rhine from Basel to the mouth of the Neckar. The latter undertaking has given the great river a continuous, closed bed which it has harmlessly followed throughout the past 100 years.

For this stupendous project Tulla needed engineers who were well trained theoretically. Together with a comrade, the architect Weinbrenner, he made the first move towards founding a higher technical school at Karlsruhe. Following the lead of Karlsruhe, a series of higher technical institutions developed, from which came numerous engineers with superior technical knowledge. The education of these engineers was specialized to a great degree, lacking in many respects the breadth of knowledge obtained by the graduates of the older universities.

At that time graduates in law governed almost entirely the public life of Germany, occupying the leading positions in the administration of land and community. Fifty years ago, it was accepted as practically matter-of-course that even great technical concerns should be directed by attorneys and governmental officials.

Engineers of higher scientific education in Germany have conducted a long and heavy battle to alter this situation and win for themselves full equality with the other professions, in particular, law, which clung tenaciously to its prominent, powerful position over a century of development. These engineers, turning their entire vigor to technical problems and still sadly lacking in breadth of comprehension and social cleverness, could make but slow progress, especially as the lawyers had the advantage of coming from families of the same profession, for (*Continued on page 304*)

TRANSLATOR'S

In the adjacent articles Professors Rehbock and Probst discuss for readers of The Review several of the more prominent transformations now occurring in the German educational system, noting the increasingly important rôle taken by German engineers in public and social affairs.

It must be realized that these discussions deal with only the Technische Hochschule, *which provides Germany's highest form of technical education. There also exist in Germany technical trade schools, which correspond somewhat to our coöperative courses here at the Institute, but do not give the same degree of theoretical training. The* Technische Hochschule, *on the contrary, probably exceeds the average American engineering institution in its fundamental instruction in physics, mathematics, and mechanics, retaining this theoretical attitude throughout the more practical undergraduate courses. Instruction is offered entirely through the lecture system, together with the necessary laboratory and design work — in all of which the student is allowed the maximum of freedom and independence.*

Hence the German system caters more to the exceptional student, as opposed to the American method of developing the majority perforce to a standard set by the average undergraduate. This underlying principle might be seen from an anecdote often related about Bismarck; he was reproached for the German educational methods by the statement "Half the students in your universities loaf their time away." "To be sure," he retorted, "but see what the other half is accomplishing."

However, altogether too pertinent to be ignored is another problem which has faced Germany throughout the past decade, a problem which we in America are just beginning to face as President Compton pointed out in the last issue of The Review. In recent years a steady decrease in employment has accompanied a growing registration in the technical universities, with the obvious result that the land can offer positions to only a small portion of the graduating engineers. Depression may account for a fair share of this increase, for tuition is surprisingly low; but German students too are adopting the lamentable American atti-

and His Battle for Public Recognition

How Educational Defects Limit the Engineer. The Problem of Over-Specialization

By Emil Probst

THE education of the German engineer — when one considers the leading engineer — for both profession and life is fundamentally different from that of the American, as are also his later place in life and his ultimate goal.

For the majority of American engineers, there exists as a final goal the position of independent consulting engineer at the service of governmental and industrial authorities, by whom they are enlisted as confidential advisers and given far-reaching power and responsibility. In Germany, however, this branch of the profession is encountered only in exceptional cases. For a long time it has been the aim of many German engineers to obtain permanent state positions in order to secure for themselves and their families a reliable occupation. Others choose paths which lead to the direction of concerns for contracting or for engineering management, or of other branches of industrial enterprise.

Before the German engineer begins his specialized education at the *Technische Hochschule* (technical university), he has to complete at least 13 years of general schooling, making him some 20 years of age when he arrives at either the university or the *Hochschule* to start his professional training.

But it must be admitted that both in German economical and technical professions the opinion is widely spread that confining youth to the school desk over so long a period must be a fault of organization. Hence the question of reorganization has arisen again and again during the past two decades.

It must be remembered that general opinion is against the qualitative weakening of the basic education in the preliminary (*Volkschule*) and secondary schools (*Gymnasium, Realgymnasium, Realschule*). More than ever before, the engineer of today and tomorrow must be capable of presenting his own ideas and those of his coworkers in adequate form, if he is to attempt the leadership of governmental or important private ventures. He must be, therefore, in a position to express himself accurately and command his mother tongue in both speech and writing; and next to securing the foundation in natural sciences, he must study foreign languages in order to be able to give heed to international relations.

These indispensable qualifications of the modern, educated man are often lacking, since the school curriculum is overburdened with irrelevant subjects. A number of general preparatory schools still delight in the point of view that without Latin and Greek one may never hope to become cultured. The result is that there are schools in which the Latin and Greek courses predominate to the detriment of other requisites. Whether it will be possible to shorten the time spent in the preparatory schools is questionable, for our desire is rather to deepen the general education than to weaken it. At all events, serious efforts are being made to secure a uniform preparatory course both for the technical school and for the university.

Here attention must be called to a general misunderstanding in America, where the name *Technische Hochschule* is often mistaken for "high school." The latter is, in German, *höhere Schule. Technische Hochschule* is identical with university, of which, however, it is independent. There are, nevertheless, serious thinkers who hold the assimilation of the former by the latter, as in England and (*Continued on page 303*)

PREFACE

tude that a college education is the primary essential of worldly success.

Three years ago the Verein Deutscher Ingenieure *(Society of German Engineers) published an article bewailing this useless overcrowding of the technical field, with the earnest recommendation not only that no new technical universities be founded, but that the matriculation in those already existing be restricted. A number of pertinent facts are to be noted in the following excerpts from this article:*

"More than ever before are young people thronging to the higher schools. They hope in this way to insure for themselves an especially desirable place in life by overcoming a few difficulties during undergraduate days. Ignorance of the actual employment outlook and an overvaluation of the social advantages of the learned professions are the real causes of this situation — and not, perhaps, only a love for Science. . . . The overrating of school knowledge is involved with an equally false underrating of what man learns in practical life. History and our own experience show how important the school of life is to professional success.

". . . among a terrific number of employment seekers (cases are named of 300 and more applications for a single position) often only a few really capable men are found. This proves that the percentage of outstandingly qualified young men among a given number of the population may not be appreciably increased by mass enrollment in the higher schools. The overcrowding of the universities has, on the contrary, a narrowing effect upon the educational possibilities. Hence it must be accepted as an established fact that this thronging to the technical schools is not a result of the real need for academically-trained engineers, but instead of the unhealthy overestimation of the value of a university education. . . . Not only college diplomas and the accompanying qualifications they represent, but above all else a man's performance both before and after — this must be the standard of qualification for the engineering profession."

Hunter Rouse

GEORGE EASTMAN

BENEFACTOR OF EDUCATION

"The Mysterious Mr. Smith" Whose Interest in M. I. T. Extended Over Nearly Half a Century

By Carl W. Ackerman

His Death on March 14 Was an Irreparable Loss to Industry, to Science, to M.I.T., and to the World

The de Laszlo portrait of George Eastman (1854–1932) which hangs in the Corporation Room at M. I. T.

ONE of the paradoxes of the last half century of progress in the United States is the contribution which self-educated industrialists have made to the progress of education. This has not been exclusively financial, especially in the case of M. I. T., for George Eastman's interest in this institution covered a span of more than 40 years and during the greater part of this period he was an inconspicuous and detached student and beneficiary.

During these years of industrial expansion in the United States, graduates of Technology came in increasing numbers to Rochester and to other industrial centers. As Mr. Eastman observed them and studied the annual reports of Technology, he became convinced that "the progress of the world depends almost entirely upon education." Then when he reached the distributive period of his own life, he was prepared to coöperate with and to encourage President Richard C. Maclaurin in building the Institute of Technology as it is today

Mr. Eastman himself never sought nor desired recognition. Early in his own career he had become convinced that "individuals may form communities," as Disraeli observed, "but institutions alone can create a nation." If Mr. Eastman could have distributed the bulk of his fortune as secretly as he did his income, it is doubtful whether his identity as "Mr. Smith" would be known today.

After inventing film photography and the portable hand camera, Mr. Eastman turned his attention to the need for scientifically trained men in industry. As a result of his own analysis and observation, for he himself was not a graduate of any school, he decided to apply to Technology for a young engineer who could take charge of the construction of a new plant outside the City of Rochester. In accordance with this plan, Mr. Eastman asked Professor Thomas M. Drown, Richard Perkin Professor of Analytical Chemistry, to recommend a young chemist from the graduating class, expressly stating the following: "I do not want anyone who is not painstaking, thorough, and thoroughly reliable. Harum-scarum youths are not of any account in this business." And then he added a sentence which was the foundation for four decades of continuous interest in Technology: "I have a great deal of confidence in the material you turn out at your institution."

That was in 1891. During the succeeding 21 years Mr. Eastman observed the industrial asset value of technically trained men. Following closely Dr. Maclaurin's administration, he remarked casually to Frank W. Lovejoy, ['94] his general manager, that he would like to meet the President of Technology. On March 1, 1912, President Maclaurin's first letter reached Rochester. It read as follows:

> A few weeks ago I had the pleasure of spending a morning on a visit to your Works at Kodak Park, and was so much impressed by what I saw that in public addresses and private discussions ever since, I have referred to these Works as a striking illustration of how a great modern industry has been built up by the application of scientific methods to manufacturing, business, and the arrangement of buildings. My experience in Rochester was incidental to a visit to Alumni Associations of Technology in various states — a visit projected with the object of interesting the Alumni of this Institute in the great problems of development with which it is now confronted.
>
> The Institute was founded 50 years ago for the purpose of training men to apply modern science to industry in all its phases. It began in a modest way and has steadily grown in size and influence until today its power is felt all over the land, and its graduates are found everywhere contributing to the national wealth by their trained intelligence and skill.

It began as a local institution, but is now a national one, with students in large numbers from every state in the Union, and over a hundred from foreign countries. The Alumni, who know it best, are enthusiastic as to its accomplishments, but they may perhaps be too near to take a proper perspective of its real importance. However, there is no lack of testimony from unprejudiced sources as to the value of the Institute's training. Thus, Sir William Mather, a prominent business man in England, reported to a Royal Commission in London with reference to this Institute, as follows:

"The spirit and energy of the students, their conspicuous practical knowledge, the thoroughness with which their scientific knowledge is tested in the course of instruction, and the power of adaptation and resource they possess on entering workshops and manufactories, railroads, or mines, public works and constructive engineering — all these fruits of the training of this Institute are, so far as I have seen, not equalled on the Continent. I think these are the qualities we need in England."

A few months ago, Dr. Bryce, a distinguished educator from Canada, stated that after visiting all the leading technical institutions in the world, he could say unhesitatingly that no technological school was to be found anywhere ahead of the Massachusetts Institute of Technology. And Mr. Edison has very recently said: "For 40 years I have been employing young men. I have taken them immediately upon graduation from technical schools and set them to work in my mills and I have found that the graduates of the Boston Tech have a better, more practical, more useful, knowledge as a class than graduates of any other school in the country. If every state in the Union had such a technical school, it would be a great thing for this country. It would bring our national problems far nearer to solution; it would improve our business conditions; and it would teach us how to grapple with the evils of the day in a competent and sane manner. There is no question but that the Massachusetts Institute of Technology is the best technical school in the country."

The steady growth of the prestige of the Institute has had the natural effect of increasing its numbers beyond the limits of its capacity, in spite of its high fees, until today its present equipment is inadequate for the demands that are made upon it. It has, therefore, been deemed expedient to provide adequately for future expansion by removing the Institute to a new site, where it can grow freely. A site of 50 acres has been purchased in the very center of greater Boston — a tract of land with a frontage of a third of a mile to the Charles River Basin. This site is ideal for the Institute's purposes, near to the heart of things, wonderfully accessible from all points of the city and surrounding country, and occupying a position that commands the public view and must command it for all time. Having purchased this site, we are now making a careful study of the problem of rebuilding, and have been fortunate in securing the services of one of the most prominent engineers of the country — Mr. John R. Freeman ['76] — to assist us with the engineering phases of that problem. We realize that we can learn much from commercial buildings of the better type, in the erection of buildings that are carefully planned so as to meet the actual needs of the Institute. These buildings must be worthy of a great institution of learning, but, though dignified, they must be simple, and they must be arranged so as to give the maximum of convenience for the minimum of cost, due attention being given to fundamental problems of lighting, heating, ventilation, and the like. In carrying out this work of rebuilding, we shall have the assistance of an enthusiastic body of Alumni, but the growth of the Institute has been so marked in recent years that considerably more than half its graduates have gone forth within the last decade. This means that they are a very young body of men, and consequently that few are in a position to help in any very large way financially. Fortunately, there are in the country men of large vision who appreciate the national importance of such institutions, and are ready to help where they are convinced that encouragement is deserved. A recent communication from Mr. Frank W. Lovejoy suggested that you may be ready to lend a helping hand, and I am writing to say that I should welcome an opportunity of placing our plans before you. I should gladly visit Rochester, if a time could be arranged that would be mutually convenient.

In reply Mr. Eastman suggested a meeting at the Hotel Belmont in New York City. Here these two men met for the first time, Mr. Eastman with an Oriental capacity to conceal his thoughts, and President Maclaurin with his Occidental enthusiasm and confidence. Dr. Maclaurin related the story of Technology's half century of educational effort, cramped now by a lack of adequate facilities and funds. He painted his picture on such a vast canvas and in such a manner that it appealed to Mr. Eastman's imagination; so much so, that he

Mural paintings decorating the Eastman Theater of the Eastman School of Music, Rochester, New York. The new Physics and Chemistry Building now being completed at M. I. T. is known as the George Eastman Research Laboratories

almost missed the midnight express back to Rochester. If Dr. Maclaurin failed to sleep at all that night it would not be surprising, for he had found "Tech's Santa Claus," a man who wanted to help, and who asked nothing in return.

"When I first came to Technology," Dr. Maclaurin recalled later, "and had time to take observations, I found that the Institute was in the doldrums. It wanted to move, but couldn't get a move on. It was clear that someone was needed to give a real push; and so, after consultation with my colleagues, I went to describe the situation to [T.] Coleman du Pont ['84, then President of the Alumni Association]. I described the broad features of our condition and said that we must move to a new site. He asked what sites were under consideration and wanted a brief description of each.

"The first one I mentioned was 25 acres in area. He said: 'Can't you double it?' and I said: 'Not this particular site.' 'Well,' he said, 'I don't like the look of 25 acres. It seems to me too small. Almost invariably when a man comes to me to approve plans for a new factory [du Pont was then President of E. I. du Pont de Nemours and Company], I tell him to double the size of everything, and almost invariably I wish afterward that I had used a larger factor of safety. Technology will occupy a great position in the future and must have room to grow. I don't feel much attracted by 25 acres, but I should be interested in 50.'

"I agreed with his policy, but told him, of course, that the main obstacle was cost. 'What would 50 acres cost?' he asked. I told him 'three-quarters of a million' and he said he would contribute half a million."

AT THEIR epochal first meeting in New York Dr. Maclaurin and Mr. Eastman went over the whole matter carefully, making the best estimates that were possible at that early stage as to the probable cost of the various portions of the undertaking. "At this meeting," said Dr. Maclaurin, "as at many others since, I could not fail to be impressed with his capacity to go to the heart of a problem quickly and see immediately what the main points are and to keep to those points in later discussion.

"He was interested in Technology's problems, but made it clear that his continued interest would depend upon its problems being tackled in a bold way and in a liberal spirit. . . . He likes things done well, but does not think they are well done unless they are done economically."

Mr. Eastman's first commitment, recorded in a formal letter March 6, 1912, was accompanied by a personal note that his name was not to be made public or mentioned to anyone.

"In confirmation of our conversation in New York yesterday, this is to say that I am prepared to give the Institute, as a building fund, the sum of two and one-half millions of dollars; the money to be used exclusively in building suitable buildings for the Institute on the new property which has been acquired by the Institute on Massachusetts Avenue, fronting on the Charles River basin. . . .

"No conditions are made as to the architecture of the buildings to be constructed, but this subscription has been made after listening to your expressions as to the inappropriateness of the Institute's indulging in any extravagant architectural features and the desirability of getting breadth of effect, more by the proper grouping and general design of the buildings than by elaborate details. One of the objects of this subscription is to enable the Institute to lay out and treat the undertaking as a whole, thereby possibly getting better results than if the buildings were erected at widely different dates."

When Dr. Maclaurin informed the Executive Committee of the gift, the largest in the history of the institution, he added that the man's name was "Smith," just "Smith" he said, with scarcely a twinkle in his eyes, and then he hastened to write Mr. Eastman that there would be no clues as to his identity in Boston.

"What I desired to avoid as far as possible," Mr. Eastman replied, "is the notoriety which oftentimes accompanies such gifts."

Of course the gift itself was not a secret. It was too valuable as a campaign wedge to justify concealment. As soon as it was announced a great guessing competition started which ran the rounds of the newspapers of the country. The competition was revived as a popular pastime on every occasion when another substantial contribution by "Mr. Smith" was announced. "At the time of the dedication of our new buildings," Dr. Maclaurin reported, "suspicion centered on two New York millionaires, each of whom strongly suspected the other. It is said that they dined together to have it out, but separated without having discovered any secrets and with enlarged respect for the bluffing power of the other. As a matter of fact, neither was 'Mr. Smith.' In another center a man, not 'Mr. Smith' claimed to be he, and in still another a woman made it known to her friends that she was certain that 'Mr. Smith' was her husband, although here she was in error."

"I have seen some of the clippings from the Boston papers containing accounts of the attempts to locate the donor and have found them very amusing," Mr. Eastman wrote Dr. Maclaurin. "The matter has quieted down now so that it looks as if the secret might be kept for some time yet, perhaps indefinitely. I am sure it would cause me considerable annoyance if my connection with the affair were made known and as I cannot see any particular advantage to be gained by so doing, I shall be happy to let the matter stand as it now is.

"I do not see why you should not take all the time necessary to perfect your plans before building, particularly as I have fixed it so that in case of my death you will get the money just the same. It is not often that an old institution has a chance to plan an entirely new outfit and it is evident that there is an opportunity to obtain a very high degree of efficiency in the layout, which, with all the talent at your command, you will no doubt succeed in doing."

Throughout the years that his business grew, Mr. Eastman recognized not only individual contributions but the larger indebtedness of industry to education. He believed that, in the future, the relationship between the two would be even more important, that the welfare and prosperity of the nation would depend upon the

coördination of industry and education to encourage extensive and intensive original thinking. To foster this ideal was his fixed decision.

After exchanging letters in regard to the architecture of the new buildings, Dr. Maclaurin went to Rochester again in June, 1913.

"In confirmation of our conversation of yesterday," Mr. Eastman wrote on June 9, "I agree to increase my subscription to the Institute building fund five hundred thousand dollars, making it three million dollars total. The object of this is to secure the completion of the whole main building as contemplated by the latest plan which you have shown me, these plans having developed a necessity for about 12,000,000 cubic feet capacity instead of 10,000,000 as originally talked and also providing for the use of Indiana limestone as a facing material on all outside walls except those which are intended to be masked by the School of Naval Architecture and by future extensions. It is understood that if the total expense runs over the amount of my subscriptions, the Institute will supply whatever funds are lacking and apply them on the foundations and the interior fittings, such as electrical wiring, plumbing, or heating as the case may be; thus leaving my subscription to cover the building first and those other items afterwards as far as the fund of three million dollars will go."

IN THE meantime the European War broke out and communications between Mr. Eastman and Dr. Maclaurin were more or less infrequent until in February, 1916, when the President penned a hastily written note to Mr. Eastman.

"I have just heard by accident that Mr. A. D. Little, ['85] a member of the Corporation of this Institute, is going to Rochester today in the hope of seeing you and interesting you in a project for the strengthening of our Department of Chemistry. His cause is a most laudable one, but of course he would not venture to [illegible] you in the matter, if he had any inkling of what you had already done. I could not dissuade him from his project without revealing your identity as a benefactor. I do not feel free to do anything that would even point the way in that direction."

The President of Technology was much more worried than Mr. Eastman, who received Dr. Little and listened patiently to the fullest exposition of the plans of the Visiting Committee for the Department of Chemistry and Chemical Engineering. Although Dr. Maclaurin had forwarded Eastman also a confidential copy of the committee's recommendations, Rochester's silent citizen listened as if he were totally unacquainted with the developments along the Charles River. Mr. Eastman was interested in Dr. Little's proposals as it involved "the extension by the Institute of its facilities for industrial research."

Dr. Little could not have selected a theme that was closer to Eastman's ideal, or one that would have expanded his interest in the Institute more than that of research. Eastman listened and questioned his caller without indicating that he had ever previously given a copper to education. When he wrote Dr. Little within a few days agreeing to furnish the total sum of three hundred thousand dollars which the committee required, the head of the Little Laboratories was so overwhelmed that he wrote Mr. Eastman that he was "quite unable to express" his "deep sense of appreciation of your splendid generosity toward the Institute of Technology."

Kodak Park and the huge plant of the Eastman Kodak Company, Rochester, New York

There appears to be little doubt that Dr. Maclaurin, too, was surprised, but Mr. Eastman enjoyed the game so much that he permitted the Institute to make a public announcement of his name in connection with this gift. This was a fine stroke of strategy, for no one thought that the anonymous "Mr. Smith" would make a public contribution.

The incident caused President Maclaurin to change his method of approach. At the time, he did not realize, perhaps, that Mr. Eastman never did anything impulsively, that his casual manner was only a cloak to conceal the intense study and thought which he had given to the problems and possibilities of the Institute. So, for the first time President Maclaurin wrote that he would like to discuss "the larger problems of the Institute's future policy. Your interest and readiness to help have been so remarkable that I should naturally seek to profit by your judgment and business experience in dealing with the larger problems with which we are confronted."

AFTER another long conference together, Mr. Eastman wrote Dr. Maclaurin the following:

In order to close up my previous subscription of $3,500,000, I have requested the Bankers Trust Company to forward you a check for $21,886.15 which with interest credited $178,113.25 and cash $3,300,000, previously paid, makes a total of $3,500,000.

In order to help you carry out your program, for further equipment, increase in salaries, and so on, I make you the following proposition: If the Institute will raise $1,500,000 additional for its endowment fund between now and the 1st of January, 1917, I will contribute a further sum of $2,500,000, the principal of which is to be used only for extending the main educational building when and as required. The income from any unexpended balance of this sum may be used for current expenses. Payment of the amount to be made in sums of $500,000 as fast as you complete the collections of the sum of $300,000 on the fund of $1,500,000 above referred to. In case the Institute is unable to raise the full sum of $1,500,000 before the 1st of January, 1917, I shall be obligated only for a total sum in proportion of five to three upon what it has raised toward said fund of $1,500,000.

I make the same request in regard to not disclosing the source of this offer that I made in regard to the $3,500,000 contribution.

This was another surprise for Dr. Maclaurin which he naturally acknowledged immediately. On the 15th he described the reception of the announcement to the Alumni.

We have just completed a three-day celebration of the opening of our new buildings. I am told that between forty and fifty thousand people were present and the utmost enthusiasm prevailed. For the first three days of the week, admission was confined to invited guests, but for the rest of the week the buildings are to be open to the public. I shall have forwarded to you some newspaper accounts of the proceedings.

Since I wrote you last, a special meeting of the Corporation of the Institute has been held to accept the extremely generous offer contained in your letter of June 3d. The Corporation appointed a committee to draw up a statement expressing the thanks of the Institute for your continued liberality and its appreciation of the splendid opportunity that is thus presented to Technology to become the greatest school of applied science in the world. . . .

The public announcement of your great gift was made by me at the banquet held in Symphony Hall last evening. The banquet was in itself a notable affair, especially as we had the opportunity of speaking to 36 different groups of Alumni scattered throughout the length and breadth of the country.

The announcement of your gift was received with the greatest enthusiasm everywhere, and I think you would have been interested in hearing the cheers that were given simultaneously from the 36 cities that were on the lines (long distance telephone lines). During the evening the President of the Alumni Association, Mr. Stone (of Stone & Webster, and also President of the American International Corporation), presented a volume of original drawings representing different aspects of the new buildings and charged me with the pleasant duty of transmitting this to you with the compliments and the most hearty appreciation of the Alumni Association. I hope that I may have the pleasure of conveying this to you in person at any time that suits your convenience.

The announcement of this great gift so stirred the enthusiasm of the Alumni present that a million dollars was subscribed during the evening . . . it has made such an impression on everyone who has heard of it that the lasting benefit to the Institute must be great indeed.

Again the national guessing contest was renewed. Who was "Mr. Smith?" The clues reached many cities; but not Rochester, for, although approaching his 62d birthday, Mr. Eastman was unknown nationally as a philanthropist.

Before the time limit expired, the Institute succeeded in raising the sum and everything was quiet along the Charles and Genessee Rivers until June, 1919, when Dr. Maclaurin came to Rochester for another secret visit. While at breakfast, he outlined his plans for raising an additional fund for the Endowment, and Mr. Eastman, as usual, was vitally interested, as indicated by his letter.

"Just to have the matter on record, I repeat my oral offer as follows: That I will give the Institute, for endowment purposes, five thousand (5,000) shares of Kodak common stock, providing the Institute will raise an additional sum of three or four million dollars. I prefer to set the sum at four million but leave that to you. The time limit is December 31, 1919. In case the Institute is not able to raise the sum I will donate a lesser number of shares, in proportion to the amount raised."

There was no stipulation this time as to secrecy but now it was in the interest of the Institute to utilize the pulling power of the mysterious "Mr. Smith."

October 15, 1919, Mr. Eastman wrote thanking Dr. Maclaurin for the airplane pictures of the Institute, received at a time when the newspapers had, for the first time, located "Mr. Smith," although neither Dr. Maclaurin nor Mr. Eastman would satisfy public curiosity.

"Enclosed is a clipping from a local paper," Mr. Eastman wrote. "I conclude that you were pestered yesterday by a flock of telegrams from this town inquiring about the Boston rumor. The only reason I ever had for withholding my name from connection with my original gifts to the Institute was to avoid the nuisance of the notoriety of big giving. My connection with several transactions lately has by force of circumstances done away with this reason and in any event the transfer of stock involved in my last offer would make my name public, so this is to let you know that you are now at liberty to make any announcement you choose in regard to my share in the whole affair. I consider that I have saved myself annoyance somewhat at your expense heretofore and it will no doubt be a relief to you to get the matter off your mind."

THE Institute launched a successful nation-wide drive to raise four million dollars to equal the approximate market value of the Kodak shares. Sunday morning, January 11, 1920, newspapers throughout the country broadcast the announcement made by General du Pont: "Mr. Smith is George Eastman."

Not even the echoes of this dramatic announcement, however, ever reached Dr. Maclaurin, for his life work reached a tragic end four days later.

"The shocking news of Dr. Maclaurin's illness and death has kept me from acknowledging your courteous letter of January 15th," Mr. Eastman wrote General du Pont. "I feel that the loss of such a man is almost irreparable, not only to Technology but to our country as well. As I have talked to him and learned of the scope of his plans and ambitions for Tech and its place in the development of this country, I can estimate in a measure the tragedy of losing him at this time. You who have been in closer relation to him are able to realize this more keenly.

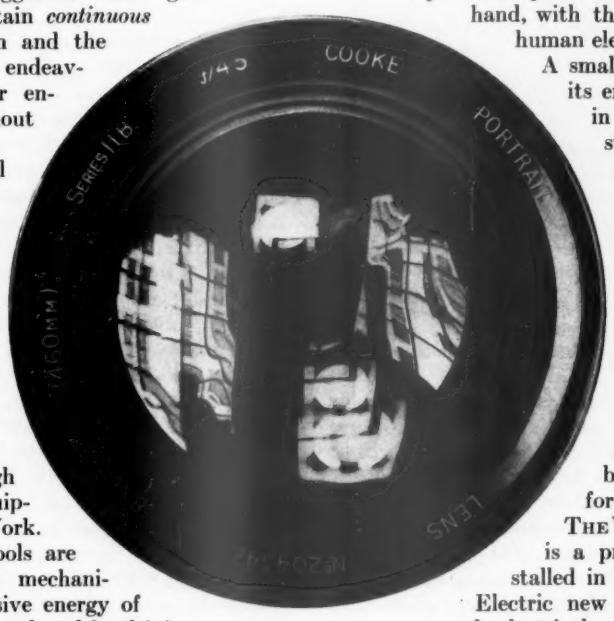
"Helping to make those plans possible — which, by the way, I first learned of by studying his yearly reports — has appealed to me (*Continued on page 302*)

THE TREND OF AFFAIRS

IN THIS SECTION: A Remarkable New Insulating Brick (294); Metal Veneers (289); Approaching the Perigee of Coldness (290); Statistical Abstract on Transportation (291); Sea Gulls as Submarine Detectors (291); Population Studies in Cleveland (292); The Roebling Family, a Book Review (292)

Putting Guns to Work for Industry

USE of *powder* as *power* adaptable mechanically for industrial purposes was proposed by Christian Huygens as early as 1680, but not until the present decade has any progress been made toward that goal. Huygens suggested that gunpowder be utilized to obtain *continuous* motive power, and Papin and the Abbé Hautefeuille later endeavored to build gunpowder engines, but, of course, without a modicum of success.



Gunpowder's industrial use lies in a different direction — in pressure tools. The late Robert Temple, an Englishman, first devised and patented what he called an "explosively-actuated affixing device." His work, initiated by a desire to gain access to sunken submarines, has been carried on by his son, Robert, Jr., through the Temple Velocity Equipment Company, New York.

The Temple Velocity tools are essentially machines for mechanically harnessing the explosive energy of powder so that it may be employed for driving rivets, for forcing studs or bolts through metal, for pressure joining, and for a multiplicity of other uses. By delaying the release of energy produced by burning powder in confinement until its maximum pressure has been reached, then letting it all go at once, these Temple guns, weighing from 10 to 15 pounds, produce Gargantuan smacks. Furthermore, they operate without noise or appreciable recoil.

THE VELOCITY DRIVER, in its smaller size (weight 8 to 10 lbs.; length 13″) takes $\frac{5}{16}$″ studs. The larger size (weight 15 lbs.; length 18″) is designed for ½″ studs and will drive hollow, threaded, or tapered studs or a solid pin through a steel plate 1⅜″ in thickness. It will perform this feat without utilizing previously drilled holes, and the depths of penetration may be controlled.

The driver may be equipped to operate under water, and thus may be used for attaching studs to sunken ships, for fastening patching plates on ship hulls without benefit of dry docks, and for driving pipe nipples through the hulls of sunken submarines so that oxygen and liquid food might be sent to a trapped crew.

THE VELOCITY PRESS is used for pressure joining. This machine was developed at the specific request of utility companies who desired a small, efficient device which could be readily used either for low tension work in manholes or for high power lines above ground. Up to the present time, due to restrictive space, the majority of cable splices underground has been made by hand, with the natural loss of time and human element involved.

A small blank cartridge, exerting its energy upon a piston, which in turn impacts on a die, instantly will compress a connector sleeve containing an insert of wire cable. The result is a solid mass of either steel, copper, or aluminum, giving excellent conductivity. These machines are light, compact, and can readily be designed to develop tremendous energy at extremely low costs. For most cables a 22-caliber blank cartridge is sufficient for the charge.

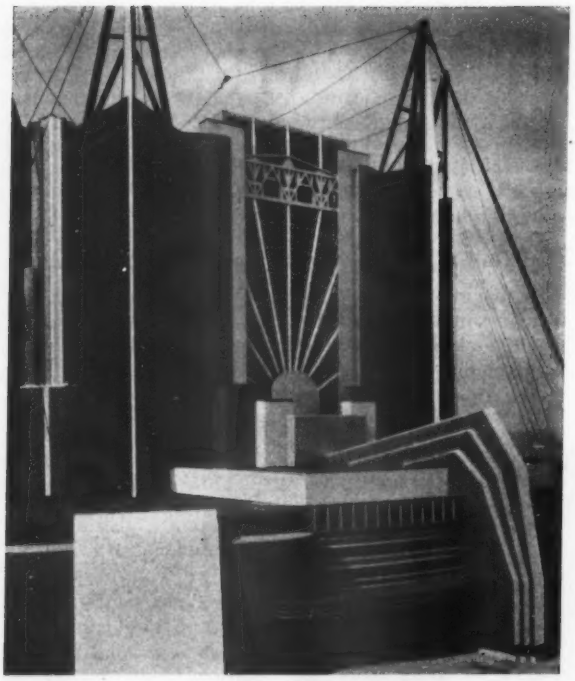
THE VELOCITY CIRCUIT BREAKER is a protective device to be installed in Westinghouse and General Electric new work systems for underground electrical service. This is a rugged device, actuated by a small charge of powder, ignited by a fuse wire. The explosive force is in back of a ram which, in turn, is in contact with a heavy copper strip. Upon discharge, the energy developed bends back the copper strip — thus breaking the circuit. It is practically noiseless in operation, and positive in action.

It is conceivable that the guns will be adapted to many other uses, particularly for jobs where power for air pressure or welding is unavailable. A small gun for killing beef is an interesting though seemingly far-fetched application. Where air hammers cannot be used, a single blow from one of these guns will head rivets.

Metal Veneers

THE development of veneers of metal on metal, wood, felt, asbestos, and even thin paper is opening up new fields in which beauty and utility are combined.

From an economic point of view, these combinations are of great importance. The high cost of certain metals has in the past prohibited their use for many purposes



The illustrations on this and the opposite page are of the Travel and Transport Building of Chicago's 1933 World's Fair. Above is shown one of the entrances to this unique structure, and below is a construction photograph of the dome which roofs one of the largest unobstructed areas ever enclosed by man

for which they are now employed in the form of thin corrosion-resisting veneers over a cheaper metal

Pure nickel is being found adaptable as a veneer on steel in the chemical industry, including the lining of tank cars for the transportation of caustic soda and chemicals employed in the rayon industry. This veneer solves a vexing corrosion problem most satisfactorily.

Another veneer of rustless metal applied on ordinary open hearth steel has already been widely used in the automotive industry. It is employed for bumpers, lamps, hub caps, decorative devices, tubing, windshield stanchions, and other parts. It can be drawn, spun, and formed to any shape as readily as solid metal. The veneer can be applied on one or both sides of the metal.

The Mellon Institute of Industrial Research has just announced a new "protected" metal. This is a laminated metal-felt product in which felted materials are cemented to steel by heat and pressure. The adhesives are metal. This new protected metal is said to promise great flexibility in providing corrosion-resistance for the materials to which the metal is bonded may be chosen to meet the demands of special applications. It can also be developed as a fireproof material by bonding with asbestos and is said to afford excellent insulation.

The use of metal veneers for decorative purposes, particularly in architectural treatments, has unusual and far-reaching possibilities. Some of these uses are clearly indicated by the materials now available. Among them are various kinds of laminated woods faced with metals. Still another is paper with a thin metallic coating laid upon it by a new method of spraying liquid metals.

The rapid development of veneered materials indicates the coming of additional achievements in a field of almost limitless possibilities.

Nadir of Coldness

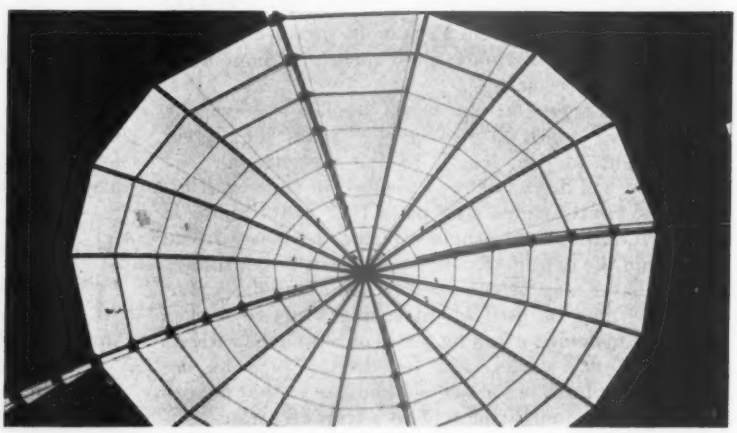
ALTHOUGH the public has heard little of cryogenic (low temperature) research, investigations in this field have developed vigorously in America within the past few years. The significance of this work lies in the fact that liquefied gases possess certain attributes that suggest that they may eventually have very practical applications in everyday life.

J. B. S. Haldane has pointed out that liquid hydrogen is, weight for weight, the most efficient known method of storing energy, because it gives three times as much heat per pound as gasoline. In time, motors may be developed to utilize liquid gases as fuel. Already rocket motors have been devised which utilize liquid oxygen mixed with gasoline.

In 1908, Professor Kammerlingh Onnes of Germany liquefied helium gas, an achievement which was later duplicated in this country by research scientists in the Bureau of Standards. Recently, Dr. W. Keesom of Leyden University, a co-worker of Onnes, succeeded in cooling a space of ten cubic centimeters to within 0.75 of a degree of absolute zero.

It was Lord Kelvin who, in 1848, announced a scale, based on fundamental laws of thermodynamics, which arbitrarily fixed absolute zero, the point of total absence of heat, at −273 degrees C. This standard is known today as the Kelvin scale, and is based upon the law of expansion of a perfect gas. Scientists say that absolute zero will never be attained. The fact that anyone has approached within 0.75 of a degree of that goal is considered a great achievement. Dr. Keesom's work was carried out with liquid helium.

Liquid gases for such experiments are extremely difficult to handle. Highly efficient vacuum flasks, some of them with double vacuum chambers, are used for the storage of these gases.



Science is much interested in the conditions which exist in a substance at absolute zero. Lord Kelvin believed that at this temperature molecular motion would stop. It is a well-known fact that extreme cold enables metals to carry many thousands of times more current than they will carry under ordinary temperatures. At Cambridge University, Dr. Peter Kabitza is working on the problem of constructing super-electromagnets. He will be able to profit much in his researches by immersing the wires in liquid helium.

Technology's plans some day to establish a cryogenic laboratory are an indication of the realization of the possibilities that lie in future knowledge of low temperatures.

Transportation Trends

DATA bureaus keep their production lines moving briskly, unaffected by economic conditions, thereby providing constantly as nearly up-to-date international statistics as possible for comparison with U. S. figures.

Examples in the railroad field:

1. *Railway mileage* (1929) — U. S. 249,433 or nearly a third of the world's 763,462. Russia is the second country with 47,869; India next with 41,724; and Canada fourth with 40,871.

2. *Passengers* (during 1929) — U. S. 786,432,000 or 7% of world's 10,574,490,000. Germany led with 1,980,300,000; Great Britain was second with 1,704,754,000; Japan was third with 1,123,578,000; and the U. S. was fourth.

3. *Passenger revenues* (during 1929) — U. S. $6,373,000,000 or 36½% of world's $17,414,100,000. Russia ranked second with $1,528,200,000, and Germany third with $1,274 500,000.

4. *Freight in ton-miles* (during 1929) — U. S. 408,407,000,000 or nearly 57% of world's 718,541,000,000.

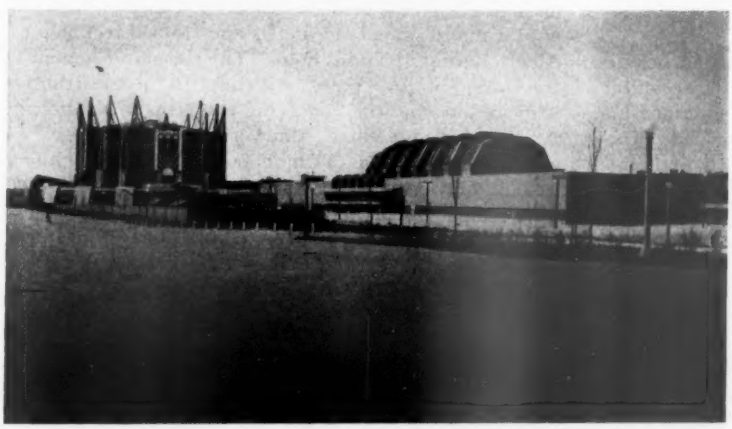
Examples in the automotive field:

1. *Highway mileage* (1930) — U. S. 3,024,233 or 38% of world's 7,959,193. Total for Europe was 2,453,160; for Asia, 1,072,408; for North and South America, exclusive of U. S., 770,873; for Australia, New Zealand, and Oceania, 380,800; for Africa, 257,668.

2. *Automobiles*, including passenger cars, trucks, and busses (beginning of 1932) — U. S. 24,132,116 or 67% of world's 35,441,933. Europe had 5,586,320; North and South America, exclusive of U. S., 2,013,977; Australia, New Zealand and Oceania, 772,287; Asia, 566,353; Africa, 370,880.

Looking upward toward the steel towers from the tops of which supporting cables run to support the dome, like a suspension bridge. This building represents the first important application to architecture of the principle of suspension support. Below is shown both the domed structure and its wing, 1000′ long

Unfortunately, world data on transportation by pipelines is incomplete. In this country last year, more than 15,000 miles of tubes to pipe gas, oil or gasoline were being laid down. Three-quarters of this mileage (7,700) was for gas (See The Review for February and December, 1931) while 4,200 miles were for oil and the remaining 3,400 were for gasoline. The total expenditures for these trunk-lines, with their feeders, have been estimated at $400,000,000, "one of the bright spots in 1931 construction" in this country.



Sea Gulls and Submarines

AN attempt by British naval officials to use sea gulls to locate German U-boats in the World War was disclosed by President Karl T. Compton in a recent address before the Twentieth Century Club in Boston.

Dr. Compton described the efforts of British seamen to train sea gulls to follow the enemy undersea craft. Using their own submarines the Englishmen cruised beneath the surface of the sea, and through openings in their vessels released food attractive to gulls.

The sea gulls followed the trails of food on the surface of the water, and in theory were to have trailed German submarines operating in English waters. But all the plans went for naught, possibly because the Germans did not leave a set trail of choice bird food, or if they did, the sea gulls had no taste for it.

Among about 20 other methods used for the equivalent of seeing submerged submarines, Dr. Compton told of the use of electrically charged wire cables and of a device involving the employment of certain types of crystals and high frequency sound waves. Similar methods, he said, have been applied to peace-time purposes, including investigations to determine what is in the outer layer of the earth's surface.

He said that two of his colleagues decided that sound waves or electric vibrations, which were used so successfully to locate hidden artillery, could also be used to determine rock formations beneath the earth's surface and to locate oil pools. Many other scientists had the same idea at about the same time, and the method is now used extensively in the oil fields.

Donald C. Stockbarger, '19

Glass blowing for science. J. E. Ryan, glass blower of the Institute's Department of Physics

Cleveland Investigates Itself

CLEVELAND, Ohio, is one of the most enlightened and enterprising cities in America, a fact that has been demonstrated in many ways, not the least of which is the record of achievement attributable to its Health Council. Not content to carry on work with inadequate knowledge of the conditions with which it must cope, this body has carried to completion the most elaborate and complete statistical population study ever made of a metropolitan area. As Leonard P. Ayres has written, "It is now true that Cleveland has more information concerning the composition, the distribution, and the characteristics of its population than exists in any other city in the world."

It is not surprising to discover that the man behind this achievement in fact-collecting is an engineer, and it is gratifying to observe that this engineer obtained his training in the Institute's Course in Sanitary Engineering. His name is Howard Whipple Green, '16, and he is director of the Health Council. His work is a convincing example of the contribution that the enlightened engineering mind can make to economic, social, and health progress.

The *Plain Dealer* Publishing Company has assembled the results of Mr. Green's study into a book entitled "Population Characteristics by Census Tracts, Cleveland, Ohio" (priced $25.00). The 28 plates, 38 charts, and 69 tables presented in this book will answer every reasonable question about the distribution and characteristics of the population making up the five-city area included in Greater Cleveland.

Not alone to the public health officer is this book valuable. The public school authorities are finding it useful in pointing their advances against illiteracy. The city planners, the transportation companies, the social workers, the bankers, and those with things to sell all find information in it contributing to their greater efficiency.

Other cities well might pause, investigate, and take heed.

Recording the Achievements of American Engineers

THE HISTORY of Engineering in America has not yet been written, or have enough adequate biographies of our more prominent engineers been prepared. There are, however, propitious signs in the heavens. Engineers are beginning to appear who can write and who have the wide culture necessary to present worthily the philosophy and history of engineering.

While these gifted ones gird their loins, we must be content with a few choice crumbs, such as the following book. It is reviewed gladly and in the hope that other engineers may receive their meed — preferably from the hands of their brother engineers.

THE ROEBLINGS, by Hamilton Schuyler, $5.00. VII+ 425 pages. Princeton, N. J. *Princeton University Press.*

Like other professions in America, engineering has at different periods been influenced by the methods and ideas of different European nations. In pre-Revolutionary days, such technical arts and sciences as were necessary were largely derived from England. The Revolution brought a close association with France and a consequent absorption of French ideas. Many French engineers came to America, and American engineers went to France for training and information.

This period of French influence lasted until the decade beginning about 1830 when a tidal wave of German immigrants swept over the Eastern seaboard, bringing with it many skilled mechanics and trained technicians. Albert Bernhardt in his book "The German Element in the United States," points out that "in the constructive work of our country, involving problems of magnitude never before presented, the German element may be said to have had a monopoly . . . the technical schools of Germany were very efficient and sent out well-trained men. . . .

"The greatest advances made in the history of bridge building in the United States were produced by two Germans: John A. Roebling, the inventor of the modern suspension bridge; and Charles C. Schneider, constructor of the successful cantilever bridge."

It is of the first of these, the gifted and prodigiously industrious John A. Roebling, and of his descendants that Mr. Hamilton Schuyler has written.

Samuel H. Gottscho

William Gehron of New York was awarded the silver medal of honor in architecture by the Architectural League of New York for his design of this memorial span over the Genessee Gorge near Rochester, New York

John A. was a young man of twenty-five when he led an expedition of German colonists to a settlement near Pittsburgh. He was an accomplished youth, holding a civil engineering degree from the Polytechnic Institute at Berlin, and embracing a philosophy derived from a close association with Hegel.

First a farmer and realtor in America, he quickly found opportunities for applying his engineering training. He secured employment as a state engineer, worked on canal projects, and surveyed a railroad route over the Allegheny Mountains which later became a part of the Pennsylvania Railroad system — a project he visualized and forecast. His wire-rope factory, the first, he established at Saxonburg, Pa., in 1841 to supply cables to replace the troublesome hemp rope used on the inclined portages over the Alleghenies.

Having developed wire rope and machinery for twisting it, it was logical that he should perceive its usefulness in suspension bridges, of which there were already a number in America, notably those built of chains by James Finley, and of wire by Charles Ellet. There is a common misapprehension that Roebling was the originator of the suspension when, in reality, his contribution was to take an old design, which contemporary engineers mistrusted, and perfect it, adding elements of strength, rigidity, and longevity. Undoubtedly, he was the first to prove it a suitable type for railroad and other large bridges.

The structure that first brought him great fame and that threw the collective engineering nose temporarily out of joint was the Niagara Gorge Suspension, completed in 1854. Fifteen years later, with many majestic bridges to his credit, his life came to a sudden and tragic close, as he was starting Brooklyn Bridge, which he conceived and planned. While taking observations on the site, one of his feet was injured and tetanus set in.

But, if John A. was not to see the realization of his magnificent conception, it was no doubt comforting to him to know that he had a son who might — and did. Washington A., the eldest of four sons, had been sent to Rensselaer Polytechnic Institute, and upon finishing had assisted his father in his great bridge projects, including the planning of the Brooklyn span. It was appropriate, therefore, that he should be appointed as chief engineer to succeed his father, and so he was in 1870, at the age of 33. From then on, his story is one of heroic fortitude. His health was permanently injured by his arduous work in the great caissons sunk beneath the river for the foundations of the towers, and he was forced to supervise the major portion of the construction from his bed in Brooklyn. But with the aid of his wife and associates, he did it, and astoundingly enough lived as a semi-invalid until 1926.

In the meantime, two of his brothers, Ferdinand and Charles, were managing the Roebling business in Trenton and building it into one of America's greatest corporations. Both, like their father and elder brother, were able engineers, and Ferdinand was endowed with great talents for business and public service. And now that they are dead their sons carry on. At the present time, John A. Roebling's living descendants total twenty-three.

Mr. Schuyler's story, then, is the saga of a mighty American family. In its high transmitting of ability from one generation to another, it equals in the field of engineering the Stevenson family in England, the Baldwin family in New England, and old James Stevens of Hoboken and his gifted progeny.

The book is somewhat scrap-bookish, although it never ceases to be interesting, and the suspicion that it is a subsidized job is of minor importance. The proof reading of the book was capriciously done. J. R. K., JR.

Two kilns: the left, lined with insulating refractory; the right, with a firebrick. The insulating brick kiln can be heated up to 2,700° F. in 50 minutes, while the kiln on the right requires five hours at the same gas rate

New Insulating Firebrick

Written by FREDERICK H. NORTON, '18

FOR many years there has been a demand for a refractory having a resistance to heat of the same order as that presented by a high grade fireclay brick, while at the same time having a degree of insulating power which would compare favorably with the better types of insulation. The brick should not only have a high fusion point, but it should be resistant to rapid temperature changes, and should show no appreciable shrinkage at service temperatures which may go as high as 2,600° F.

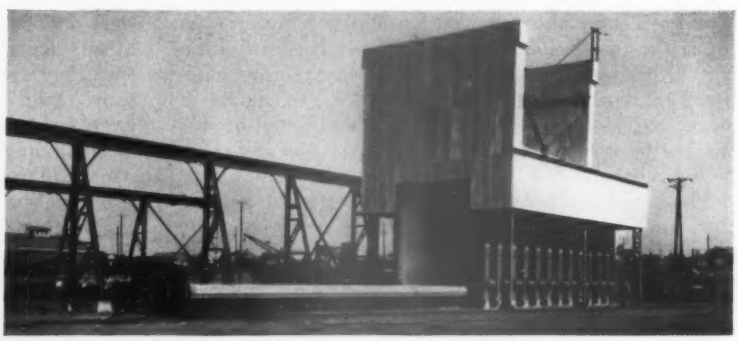
The problem of developing such a brick has been carried on at the Institute for a number of years, and a product which showed very interesting possibilities was produced in small quantities. The material used for the brick was Georgia kaolin which is a very pure form of white clay. This clay has the high fusion point of 3,200° F. A great many difficulties had to be overcome in the development of this product since the kaolin has a very high shrinkage in firing, and must, therefore, be burned to a temperature at least as high as the temperature that it will receive in use. Within the last year this brick has been placed in commercial production and most of the manufacturing problems have been solved.

The brick has a weight of about 1.7 pounds as compared with 8 pounds for a firebrick. Its thermal conductivity at 2,000° F. is 3 as compared with 15 for the firebrick. It will support a load of 6 pounds per square inch up to temperatures of 2,600° F. One of the greatest advantages of this brick is that it can be sawed and filed into any shape with great ease, which makes it possible to form intricate shapes for special furnace parts with very little expense. Due to the extremely porous nature of the material of which the brick is made, it is rather permeable to gases, and usually the inside surface of the brick lining is coated with a thin layer of cement which seals the surface pores.

This brick is particularly valuable in intermittent furnaces which must be heated and cooled rapidly. Due to its very low weight, it has been found that only 10 to 20% of the fuel required to heat up the usual firebrick furnace is needed. It is also possible to reduce the heating-up time by about the same amount which is a great advantage in furnaces that must be heated up every morning. The fuel required to hold a furnace at a given temperature is also much reduced by using this brick, as a 9-inch wall of the insulating refractory is a considerably better insulator than a 36-inch wall of fireclay brick. Another advantage of the thin walls is the fact that the outside dimensions of the furnace can be considerably reduced. Also the good insulating properties and the low mass permit a much more even temperature in the furnace than if it were lined with fireclay brick. This is very important since evenness of temperature in a furnace is often very difficult to achieve.

Above there are shown two laboratory kilns under construction. The one at the left is lined with insulating refractory, and the one on the right with a firebrick. The two kilns are identical in size, and careful comparative tests have been made on them in the Heat Measurements Laboratory. The insulating brick kiln can be heated up to 2,700° F. in 50 minutes, while the other kiln requires five hours at the same gas rate. The insulating brick kiln, therefore, requires less than one-fifth the gas to bring it up to temperature. The insulating brick kiln has a very even temperature distribution even at the start, whereas the firebrick kiln does not become even in temperature until the temperature has been balanced for some time.

Below is shown a photograph of one of the largest annealing furnaces in the world which is at the Barberton Works of the Babcock and Wilcox Company. This furnace is 60 feet long, 15 feet wide, and 22 feet high, and is completely lined with 9 inches of insulating firebrick, held on the inside of a steel casing with a few lag screws which are screwed into some of the bricks for anchors. This furnace can be heated up with the drum in place to 1,200° F. for strain annealing, in the remarkably short time of 40 minutes. The kiln is fired with natural gas and about 1,000 cubic feet are required for strain relieving one ton of steel. This shows great economy over firebrick furnaces.



One of the largest annealing furnaces in the world which is at the Barberton Works at the Babcock and Wilcox Company

Feather River Twice Spanned

The steel arch highway bridge built by the California Highway Commission over the Feather River near Pulga, in Plumas County (State Route No. 21, extending from Oroville to Quincy).

The bridge spans a railroad which passes on a bridge beneath it. The deck of the highway bridge is about 200 feet above the river and 170 feet higher than the railway tracks, which are crossed at right angles. The main arch is a 350-foot span, and the total length of the bridge is 680 feet.

That the construction was accomplished in the face of hazards and unusual difficulties is evinced by the survey pictures on the right. By ropes the surveyors descended the face of the cliffs to set stakes for the abutments.

VANNEVAR BUSH
Vice-President, M. I. T.
Dean of Engineering

Dr. Bush, a native of Everett, Mass., is the son of the late Rev. R. Perry Bush, for 50 years a clergyman in the vicinity of Boston. He was graduated from Tufts College in 1913, and in 1916 he was awarded the degree of Doctor of Engineering jointly by Harvard University and Technology.

Early in his career, Dr. Bush held a position in the test department of the General Electric Company, and then returned to Tufts College as an instructor in mathematics. Subsequently he was promoted to the grade of Assistant Professor of Electrical Engineering at Tufts, and in 1923 he joined the Faculty of the Institute.

In 1917–18, he carried on important research in submarine detection for the special board on submarine devices of the United States Navy. He now holds the commission of Lieutenant Commander in the U. S. Naval Reserve Forces. Following the World War, he was consulting engineer for the American Radio and Research Corporation. He is a director of the Spencer Thermostat Company and of Raytheon, Inc.

As Professor of Electric Power Transmission at M. I. T., he has been particularly interested in the design of scientific calculating instruments. For the development of the product integraph he was awarded the Levy Medal of the Franklin Institute in 1928. Recently he has won wide recognition for his design of an intricate calculating machine called the differential analyzer, which greatly increases the accuracy and speed of engineering calculations. (See The Review for January, 1932.) He is also known for his contributions to the development of vacuum tubes, for his investigations in electric power transmissions, and for his conception and development of the network analyzer. Dr. Bush has also carried on important studies of transients in machines and dielectric phenomena.

Dr. Bush is a Fellow of the American Institute of Electrical Engineers, the American Academy of Arts and Sciences, and the American Physical Society. He is a member of the Society for the Promotion of Engineering Education, and of Alpha Tau Omega, Tau Beta Pi, Kappa Eta Kappa, and Phi Beta Kappa fraternities.

Besides numerous papers in periodicals, he is author of "Operational Circuit Analysis," and joint author with Professor W. H. Timbie of "Principles of Electrical Engineering." He is an enthusiastic yachtsman and during the summer makes along shore cruises on his yacht, the Caribou.

The New Administrative Organization at M. I. T.

APPOINTMENT of Dr. Vannevar Bush, Eng.D., '16, as Vice-President of the M. I. T. was announced by President Karl T. Compton following the regular meeting of the Corporation of the Institute on March 9. Dr. Bush has been a member of the Faculty of the Electrical Engineering Department since 1923, and is noted for his achievements in research and contributions to technical education (see above). With his appointment as Vice-President, Dr. Bush also became a member of the Corporation.

In announcing Dr. Bush's elevation to the position of second in command at the Institute, President Compton revealed plans for the subdivision of Technology into the School of Science, the School of Engineering, the School of Architecture, the Division of Humanities, and the Division of Industrial Coöperation. He announced the selection of Dr. Samuel C. Prescott, '94, Head of the Department of Biology and Public Health, as Dean of Science; and Professor William Emerson, Head of the Department of Architecture, as Dean of Architecture. In addition to his duties as Vice-President, Dr. Bush will be Dean of Engineering.

Another important feature of the new academic organization is explicit recognition of the Graduate School, under which all advanced work at the Institute will be administered.

President Compton has described the new plan as follows:

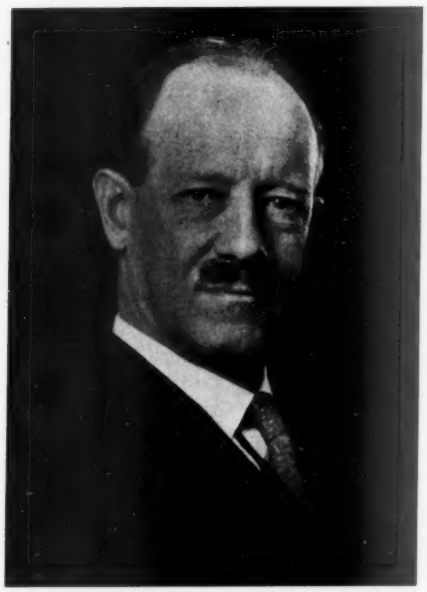
"The new plan of administrative organization of the Institute adopted by the Corporation is a natural extension of the administrative plan begun two years ago with the appointment of a Chairman of the Corporation as well as a President of the Institute.

"The subdivision of the Institute, for administrative purposes, into the School of Engineering, the School of Science, the School of Architecture, the Division of Humanities, and the Division of Industrial Coöperation, recognizes the five major aspects of its work. The three schools comprise those departments of study in which degrees are given, whereas the two divisions are essentially 'service' divisions. That of the Humanities is designed to give to our students that further cultural training and background which we deem an essential part of a well-balanced training. The Division of

Industrial Coöperation is designed to make as effective as possible the assistance which the Institute renders to business and industry in solving their technical problems. While the outstanding position of M. I. T. in the field of engineering education is generally recognized, its equally strong position in science and architecture is probably not so widely known, since these activities are not explicitly indicated in the name of the Institute.

"An important feature of this new organization is the explicit recognition of the Graduate School. The Institute has awarded approximately one-third of all the advanced degrees in engineering given in this country, and in certain departments, notably chemical engineering, electrical engineering, and aeronautical engineering, has awarded approximately one-half of all the advanced degrees. With every indication that this feature of our work is becoming relatively more important, it has seemed advisable to provide adequately for its recognition and its constructive administration.

"Although thus divided into these schools for the purpose of administration responsibility, the Faculty as a whole will continue to be the final authority.



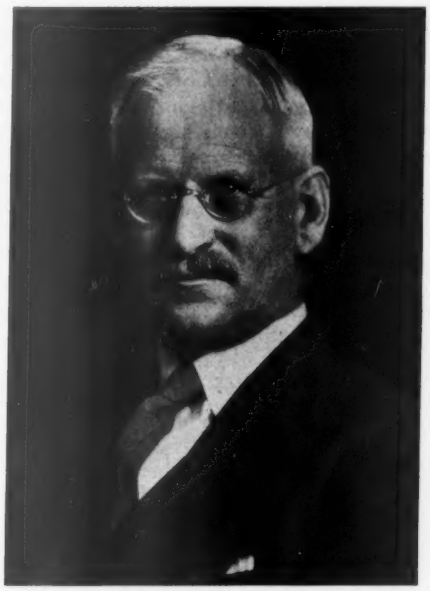
WILLIAM EMERSON
Dean of Architecture

Professor William Emerson came to M. I. T. in 1919 as Head of the Department of Architecture, following a distinguished architectural career in New York. In his professional work in New York from 1901 to 1918, he specialized in the design of bank buildings and model tenements. He is widely known for his contributions to architectural education as chairman of the educational committee of the American Institute of Architects.

Professor Emerson is a native of New York City, and was graduated from Harvard University in 1895. He then studied at Columbia University for two years, and from 1897 to 1901 attended L'École des Beaux Arts in Paris.

He served as Major and Director of the American Red Cross Bureau of Construction in Paris from 1917 to 1919, and he is a Chevalier of the French Legion of Honor. As a Fellow of the American Institute of Architects, he has been very active in the affairs of that organization, being a former first Vice-President, and a former President of the New York chapter. He is also a member and Past Vice-President of the Society of Beaux Arts Architects; a member of the Boston Society of Architects, and of Delta Kappa Epsilon; and an Honorary Member of the Alumni Association of M. I. T.

In 1928 he was elected an honorary member of the Harvard chapter of Phi Beta Kappa. Professor Emerson has been advisory architect for Radcliffe College since 1929, and a member of the A. I. A. Committee on the Pan-American Congress of Architects. In 1924 he represented the United States at the International Congress on Architectural Education Meeting in London. He was chairman of the Committee on Foreign Relations of the American Institute of Architects in 1926, which made plans for the restoration of the Church of Santa Sophia in Constantinople. He is the author of "Old Bridges of France."



SAMUEL CATE PRESCOTT
Dean of Science

Dr. Samuel Cate Prescott, '94, Head of the Department of Biology and Public Health at M. I. T., is internationally known for his work in the application of biology to industry. He was Director for many years of the Boston Bio-chemical Laboratory, and for three years directed a laboratory in Costa Rica in which were carried out important studies on soils and diseases of tropical fruits for the United Fruit Company.

Dr. Prescott was born in South Hampton, N. H., of old New England stock. He began his teaching career at Technology in 1895 and in 1900, he spent several months in postgraduate work in Berlin and Copenhagen. He returned to Technology and was made Assistant Professor in 1903, Associate Professor in 1909, and was promoted to the rank of Professor in 1914. When Professor Sedgwick died in 1921, Dr. Prescott was made Acting Head of the Department, and he was appointed as permanent Head in 1922.

During the war, Dr. Prescott served in the U. S. Sanitary Corps with the rank of Major, in charge of food research and the problems of storage at the great army training camps. This work included the development and specifications for dehydrated foods sent to troops abroad. As an outgrowth of this work, in 1918–19 he was also chief of the division of dehydration of the Bureau of Chemistry in Washington. He now holds the rank of Colonel in the Officers Reserve Corps.

Dr. Prescott is a Fellow of the American Association for the Advancement of Science and of the American Academy of Arts and Sciences. He is a member of the American Chemical Society, the American Society of Naturalists, the Society of Chemical Industry, and the American Public Health Association. He is a member and Past President of the Society of American Bacteriologists and of the Technology Alumni Association. He is a member of the Lambda Chi Alpha Fraternity.

"Because of their high standing in their professions, their thorough knowledge of the affairs of the Institute and their personal qualifications, I believe that the addition of Deans Bush, Prescott, and Emerson to the administrative staff will result in a marked increase in the amount and quality of the service which this Institute can render through its work in education and in the advancement of knowledge."

The new organization provides for an Administrative Council, an informal organization which will hold weekly meetings in order that all its members may be kept fully informed of progress in various departments of the Institute. This Council will consist of President Compton; Vice-President Bush, members of the Executive Committee of the Corporation; Dean of Science Prescott; Dean of Architecture Emerson; the President of the Alumni Association; Chairman of the Faculty Frederick S. Woods; Bursar Horace S. Ford; Professor Charles L. Norton, '93, Director of the Division of Industrial Coöperation; Dean of Graduate Students H. Manley Goodwin, '90; and Dean of Students Harold E. Lobdell, '17.

The School of Science includes Biology and Public Health, Chemistry, Geology, General Science, Mathematics, and Physics. Architecture and Architectural Engineering will be administered under the School of Architecture.

Included in the School of Engineering will be Aeronautical Engineering; Building Engineering and Construction; Business and Engineering Administration; Civil and Sanitary Engineering; Chemical Engineering; Electrical Engineering; Electro-chemical Engineering; Fuel and Gas Engineering; General Engineering; Mechanical Engineering; Mining and Metallurgical Engineering; and Naval Architecture and Marine Engineering; and Naval Construction.

The Division of Humanities will include Economics, English and History, General Studies, Hygiene, Modern Languages, and Military Science.

INSTITUTE GAZETTE

Dr. Tryon's Second Middle Western Tour

BEFORE completing his school and college visiting for the present academic year, Professor James L. Tryon, Director of Admissions, will make a four weeks' tour among educational institutions of the Middle West from which the Institute receives students for graduate work or by transfer after attending another college.

He will go as far as Denver which, owing to pressure of unexpected engagements, he was unable to include in his recent journey to the Pacific Coast. Dr. Tryon will attend the College Board meeting in New York and start westward after visiting in New Jersey and Pennsylvania.

For the vocational guidance of high school students who are trying to decide upon an occupation, he will, as usual, take as his topic "The Education of an Engineer," tell boys of high school age about the kind of studies that are pursued in an engineering school, and describe the careers that are open to graduates in science and engineering.

Dr. Tryon's itinerary follows:

NEW YORK
April 6 — New York City — College Board Meeting

NEW JERSEY
April 7 — Hoboken — Stevens Institute of Technology

PENNSYLVANIA
April 8 — Haverford — Haverford College
April 8 — Philadelphia — University of Pennsylvania
April 9 — Gettysburg — Gettysburg College
April 11 — Mercersburg — Mercersburg Academy

OHIO
April 13 — Wooster — The College of Wooster
April 14 — New Concord — Muskingum College
April 15 — Columbus — Ohio State University
April 16 — Yellow Springs — Antioch College
April 18 — Cincinnati — University of Cincinnati
April 18 — Cincinnati — The Technology Club of Cincinnati

INDIANA
April 19 — Lafayette — Purdue University
April 20 — Lafayette — Purdue University

ILLINOIS
April 21 — Chicago — Convention of Registrars
April 22 — Chicago — University of Chicago

MISSOURI
April 25 — Kansas City — Kansas City Junior Colleges (Missouri and Kansas)
April 26 — Kansas City — Southwestern Association of M. I. T.

KANSAS
April 26 — Lawrence — University of Kansas

COLORADO
April 27 — Denver — Schools and Colleges
April 28 — Denver — Schools and Colleges
April 29 — Denver — Schools and Colleges
Date to be set — Denver — Rocky Mountain Technology Club

WYOMING
May 2 — Laramie — University of Wyoming

Baron Takuma Dan, '78, and R. H. Richards, '68, in Tokio at the World's Engineering Congress three years ago. Baron Dan, Head of the House of Mitsui, was recently assassinated

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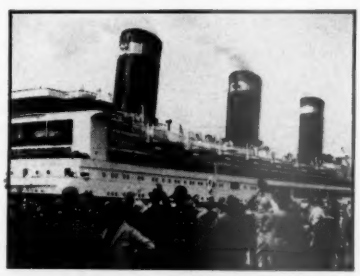

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THE MASTER KEY OF SCIENCE

(*Continued from page 281*)

interpreted as a result of the spin of the electron — thus increasing the "astronomical" resemblance of the atom-model; while the appearance of numerous terms in the more complex spectra was accounted for by differently quantized inclinations of the electron orbits. The complex multiplets of lines found in the spectra were thus fully explained. In its final form (due to Hund) this theory has been brilliantly successful in elucidating the structure of atoms and interpreting and even predicting the details of their spectra. Work in this field has been very active, and only the most complex spectra (rare earths and some heavy metals) and those of a few very rare elements, remain to be deciphered.

In the case of molecules, changes in the states of oscillation and rotation of the nuclei, as well as in the electronic states, are possible, and the spectra are much more intricate, consisting of complex bands comprised of closely packed lines. Those of diatomic molecules are now well understood — with important gains in our knowledge of molecular structure and the nature of chemical "affinity," and the still more intricate polyatomic molecules show signs of yielding. Different isotopes of the same element, when present in compounds, often give widely separated bands. From these new isotopes of oxygen, nitrogen and carbon have been discovered, and the ratio of the masses of the different atoms determined with extreme precision. In atomic spectra, the isotope effect is extremely small, except for hydrogen — where it has recently permitted the identification of an isotope of double weight.

Fine-structure in the lines of heavier atoms arises partly from the presence of isotopes, partly from some sort of "spin" within the atomic nucleus, and its study affords a promising approach to the problem of nuclear structure.

While all this was going on, x-rays were also found to contain monochromatic radiations, observable by using the atoms in a crystal as a diffraction grating. These spectra have given us information about the interior of atoms, comparable with that which optical spectra furnish concerning the exterior. They are much simpler than the latter, and now furnish the chemist with his most delicate test for the detection of new elements. Incidentally, they make it certain that except for the few well-recognized gaps, no elements lighter than uranium remain to be discovered.

Working in the opposite direction, x-ray spectroscopy opens the door to another untrodden realm — the exact study of the arrangement of atoms in crystals, which can now be specified in minute detail.

All through these triumphs ran a discordant note. Certain numerical relations — notably in the Zeeman effect — though exact, differed systematically from those predicted by the orbit theory, and every calculation based on the relative positions of electrons in these orbits led to a wrong answer. This discrepancy has vanished since the orbital picture of the atom was replaced by the difficultedly visualizable wave-mechanics

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or the wholly unpicturable matrix-theory. When a modern lecturer tries to draw an atom on the blackboard, he uses not chalk, but an eraser, and constructs a smudge illustrating the relative probability of finding a unit-charge in different regions. But as a means of calculation, — interpreting and, on occasion, predicting, the results of precise observation, the new theory advances from conquest to conquest.

The ramifications of these new ideas throughout the range of molecular and atomic physics are too numerous to mention. To take but one instance at random, the magnetic susceptibilities of solutions of salts of the rare earths may be fully explained by the theory of spectral structure — even though the spectra of the trebly ionized atoms (upon which these depend) have not yet been observed.

There is probably no field in which the new spectroscopy has been of more aid than in astrophysics. The recognition that Lockyer's enhanced lines are produced by ionized atoms, and the general application of the laws of ionization to stellar atmospheres have transformed our whole viewpoint. We know now that the disappearance of the lines of the metals from the hot stars means only that they have been so highly ionized that they no longer give lines in the observable region, and that the lines of the permanent gases, and the non-metals, generally are weak or absent in the cooler stars because their atoms are not highly enough excited to be able to absorb the observable lines. From measures of line-width, and also by study of multiplets, the actual number of atoms which produce a given spectral line may be estimated, and an approximate quantitative analysis made of the atmospheres of the sun and stars. The results indicate a remarkable similarity of composition, despite the great differences in the spectra of hot and cool stars. The relative abundance of the elements is similar to that in the earth's crust or in meteorites, with one noteworthy exception. Hydrogen — a minor constituent here — is overwhelmingly predominant in the stars. (The excess very likely escaped during the formation of our planet.) Both the temperature and pressure of a star's atmosphere may be found from the intensities of the spectral lines. The former agree with the values deduced from the colors of star-light; the latter are surprisingly small, and indicate that the atmospheres are of exceedingly low density. The whole atmosphere of the sun, brought to standard temperature and pressure, would make a layer of gas less than a hundred feet thick, of which the metallic vapors form about one per cent.

A similar conclusion was reached more than forty years ago by Lockyer, by the simple process of comparing the sodium lines in the solar spectrum with those absorbed by the vapor present in a Bunsen flame. The sun's atmosphere, of course, is not sharply bounded at the bottom; it grows hazier owing to the increasing density of the free electrons and ions, and passes into the luminous photosphere. The principles upon which this increasing opacity can be calculated are essentially spectroscopic, and the data regarding the ionization and excitation potentials of atoms, which it requires, have been derived spectroscopically. (*Concluded on page 302*)

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THE MASTER KEY OF SCIENCE

(*Concluded from page 301*)

Two more applications may be mentioned — to matter in extreme states of condensation and rarefaction.

From the spectroscopic data regarding atoms it follows that, at very high temperatures, inside the stars, they will be completely ionized down to bare nuclei and electrons. Matter in this state should be exceedingly compressible, but not infinitely so, — the limiting factor being the degeneracy of the gas (in the sense of the new quantum theory) at a density several hundred thousand times that of water. The problematical white dwarf stars, like the companion of Sirius, show conclusive evidence of being in this state, while the shift towards the red of the lines in their spectra (coming from the outer atmosphere) affords an important confirmation of general relativity. At the other extreme, the gaseous nebulae — which from gravitational considerations must be of extreme tenuity — show spectral lines which were long a tantalizing problem. Modern spectroscopy revealed the existence of metastable atomic states, from which light-producing transitions would not occur unless the individual atoms were left undisturbed much longer than they would be except in an exceedingly rarified gas. Bowen thus identified the nebular lines as "forbidden" lines of the sort produced by the most familiar elements, oxygen and nitrogen above all. The hypothetical unknown element nebulium thus very literally vanished into thin air.

GEORGE EASTMAN

(*Continued from page 288*)

as an opportunity to get considerable sums of money into effective action for the benefit of the whole country better than any other way."

"Of all the honors he received," Welles Bosworth, '89, architect of the new buildings wrote Mr. Eastman, "It was you who did him the greatest honor, in your generous confidence in him, and how beautifully your judgment was justified by his accomplishments. It seems inevitable that the great work that he has so substantially developed must go forward."

For more than a quarter of a century, Mr. Eastman had contended that "this country cannot progress industrially without plenty of highly trained technical men." Massachusetts Institute of Technology was the embodiment of this educational ideal, for here the

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interests of education and industry were welded by Dr. Maclaurin and "Mr. Smith."

Among the many letters which Mr. Eastman received was the following from President Lowell (dated Feb. 3, 1920), which, with characteristic modesty, was not shown to anyone.

Bishop Lawrence has shown me your letter to him in reply to his, which emboldens me to add my word of congratulation to you for your great gift to the Institute of Technology. I have been a trustee of the Institute for over 30 years; and labored hard to bring it and the Harvard Engineering School together; but unfortunately the difficulties were too great to be overcome.

The Institute has done and, with your assistance, is doing and will do a very great work. I have seen it built up from a small beginning, for my interest in it is hereditary, my father and grandfather having been among its trustees; and, indeed, one of the courts in the new building is named after my father. I suppose few institutions in the world have contributed more to advance industry and the practical arts; and I do not know that any man in the world has done so much to help an institution of engineering as you have done for this.

At the time Mr. Eastman's biography was being written he did not know how much money he had actually given Technology. When a tabulation was finally obtained, indicating an amount of approximately twenty million, he studied the figures for several moments, and then remarked: "In a few years that will not be very large, for Technology will grow."

HOW EDUCATIONAL DEFECTS LIMIT THE ENGINEER

(*Continued from page 283*)

America, to be preferable, but at the present time Germany is still far from such a move.

Studies at the *Technische Hochschule* take at least four or five years. At present we are in the midst of a reform movement to improve the *Hochschule* curriculum and rearrange the time schedule.

The engineer, graduating from the *Hochschule* in favorable circumstances, has attained the age of 24 or 25 years before entering practice, where, for the first time, he is to make actual use of his professional training. It does not seem to me an ideal situation that the young man of today must reach such an age before he begins to earn his living. I believe that in the near future we must, without lowering the present educational standards, find a way to permit an earlier entrance into practical life. But here again one must face the fact, already encountered in the question of preparatory schools, that the growing demands for a broader and more comprehensive scientific training of the engineer must always be taken into account.

Since the specialized training at the *Hochschule* makes heavy claims upon the prospective engineer's capacity for study, it is obvious that under present circumstances only a small percentage of the students find the opportunity to concern themselves with those subjects, however necessary, which lie outside their own special field. On that ground, only a few of them are able to compete successfully with the lawyers, business men, and business men trained in (*Concluded on page 304*)

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HOW EDUCATIONAL DEFECTS LIMIT THE ENGINEER

(*Concluded from page 303*)

law in their command of present-day affairs. Whence it comes that the number of leading positions in general life held by engineers is very small.

While in Italy, in France, and in the United States as well, it is by no means seldom that the engineer gets a leading position with the government or in a big industrial concern, in Germany such a situation is rarely found. The cause for this deplorable fact lies chiefly in the training preparatory to graduation at the *Hochschule*, and therefore a modification of this training is highly desirable.

THE EVOLUTION OF THE TECHNICAL UNIVERSITY

(*Continued from page 282*)

generations already in leading positions, and therefore in closer relationship with the responsible directors.

The *Technischen Hochschulen* have come to recognize in recent years that in order to obtain for their engineers in public life and private affairs a footing fully equivalent to that of graduates in law, they must give them, outside of their purely technical knowledge, a general education beyond that of preparatory schools.

To this end they have greatly expanded their curriculum, added to their faculties professors in other than technical fields, and established examinations in economics and administrative technique to which their engineers must submit.

A definite standard was evolved for the successful completion of all technical courses in the *Technischen Hochschulen* through the examination leading to the degree of *Diplom-Ingenieur*. For those engineers especially talented and capable of independent scientific work, the degree of *Doktor-Ingenieur* was created, thus establishing requirements at least equivalent and often superior to the doctorate examinations of the universities.

The reluctance of the best families to send their sons to a *Technische Hochschule* instead of a University has steadily diminished in the past decades, especially since the World War. Through an increasing enrollment of students from the higher industrial and administrative circles, the reputation of the *Technischen Hochschulen* has constantly improved.

In this way it has become possible, through improvement and broadening of the curricula and the consequent growing respect for the work of the engineers in all fields, to bring about the gradual disappearance of the prejudice against engineering in favor of law. If such a prejudice still exists in certain classes, it may, nevertheless, be asserted that the former decided supremacy of attorneys in technical undertakings and administration has already been broken.

Above all, the positions of leadership in private undertakings are in the hands of the engineers, and men like Vögler, C. F. von Siemens, Dorpmüller, and others command the greatest German economic organizations, including the *Deutsche Reichsbahn* (German railroad), the greatest nationalized traffic undertaking in the world.

(*Concluded on page 306*)

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THE EVOLUTION OF THE TECHNICAL UNIVERSITY

(*Concluded from page 304*)

In the government of the country it has been more difficult for the engineers to make similar progress. It is an exceptional case when ministerial posts are filled by engineers, as was the situation in Baden when the engineer Honsell, former President of the Department of Water and Highway Development, directed the Ministry of Finance of this country with great success.

At the head of the municipal government as well, one usually finds a lawyer as *Oberbürgermeister*, although the largest municipal enterprises are nearly always of a purely technical nature. But even this monopoly has already been broken several times, and it can no longer be said that the highest city positions are closed to the engineer.

To a certain extent, however, the same may be said of German engineers as is often heard in America — the reproach that they are too narrowly interested in purely technical matters, and that the general questions of political and economic life and of social welfare receive too little of their attention. This is, however, a result of that peculiarity of a technical profession which demands and imprisons the entire energy of an engineer and often makes a one-sided specialist of even the most talented. But besides these "only-engineers" there are others in Germany who are not prevented by special technical interests from obtaining a full understanding of the general questions of public life and who therefore rise to distinguished leadership in the prominent administrative enterprises.

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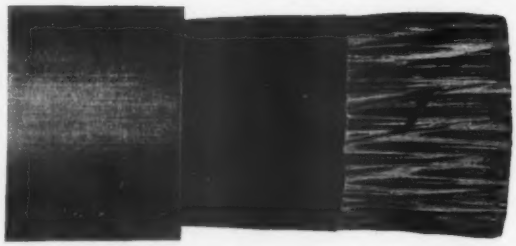

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THE TABULAR VIEW

PROFESSOR TENNEY L. DAVIS sees science steadily and sees it whole, as his article, the first in this issue, demonstrates. After graduating from Technology in 1913 he continued his studies at Harvard where he received his Master's and Doctor's degrees. In 1919 he joined the Institute's instructing staff and since 1926 he has been an Associate Professor of Organic Chemistry. Besides being a Contributing Editor of The Review, he is an Associate Editor of both *Isis* and *Archeion*, journals relating to the history of science. ¶ When the names of 28 foremost American scientists were recently inscribed on stone tablets above the entrance of the new Buhl Hall of Science at the Pennsylvania College for Women, the roster included WILLIS R. WHITNEY, contributor of the second article in this issue. This is adequate evidence of Dr. Whitney's high standing, particularly because the 28 names were selected by a poll of the 902 starred scientists listed in "American Men of Science." Dr. Whitney obtained his Bachelor's degree from M. I. T. in 1890 and he is now Director of the Research Laboratory of the General Electric Company. The article by him is drawn from the address which he delivered upon receiving the Franklin Medal of the Franklin Institute.

IT IS particularly fitting that The Review should present a survey of the development of calculating machines, since so much notable work in this field has been carried on by the Institute's Department of Electrical Engineering. The author of this article, HAROLD L. HAZEN, '24, is an Assistant Professor of Electrical Engineering and he has participated in the development of the various integraphs and analyzers that have been built by his department. He just recently presented to the Faculty of the Institute a doctorial thesis entitled "The Extension of Electrical Engineering Analysis through the Reduction of Computational Limitations by Mechanical Methods." Mr. Hazen points out the inspiration that he and his colleagues have received from the works of that great German mathematician and philosopher, Leibniz. This doubtless recalls to Review readers an article by Norbert Wiener in our February, 1932, issue entitled "Back to Leibniz." ¶ DANIEL C. SAYRE contributed the article on the vulgate of aeronautics which appeared in The Review for November, 1931. Professor Sayre, as we have pointed out before, wants it expressly understood that he is not a *modock*, a *dodo*, or a *kewee*, but a full-fledged licensed pilot. This he has demonstrated by the great skill with which he has conducted the daily flights of the airplane operated by the Meteorological Division of the Institute's Department of Aeronautical Engineering. Throughout a New England winter he has accomplished 90% of the planned flights — a record to be envied, as transport pilots will agree. Professor Sayre holds both Bachelor's ('23) and Master's degrees from the Institute, and he is an Assistant Professor on the staff of the Institute's Department of Aeronautical Engineering.